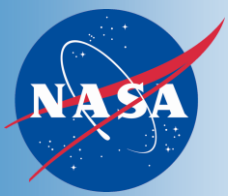




Offshore Membrane Enclosures for Growing Algae

Technology Development & Demonstration Project



What is OMEGA?

Offshore Membrane Enclosures for Growing Algae

OMEGA System

Aviation
Fuels

Algae
Production

Wastewater
Use/recycling

Solar Energy

Temperature
control

Biofuels
Fertilizer
Biochar etc.

Nutrients
(NPK)

Gas exchange

O₂

CO₂

wave en

Osmo

Carbon
Sequestration

Marine
Photobioreactor
PBR

Pollution
Prevention

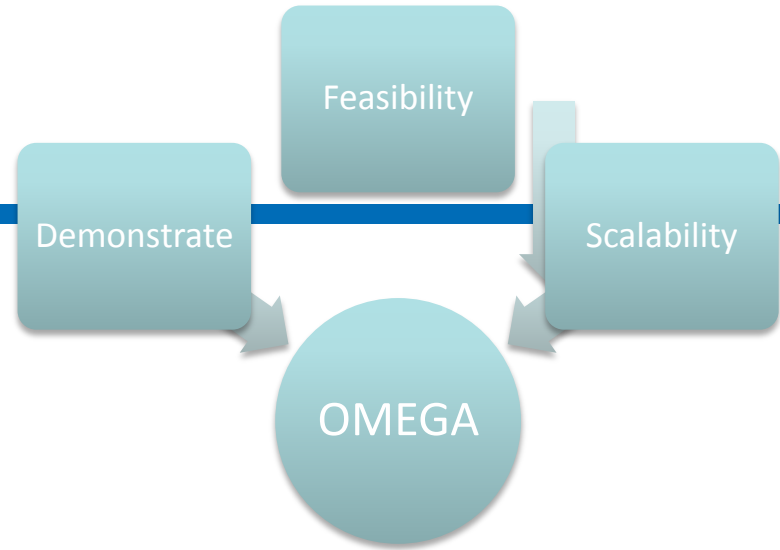
Treated Wastewater

Water

FORWARD OSMOSIS

Dewater

Nutrients

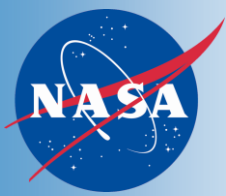


Project Overview

Offshore Membrane Enclosure for Growing Algae

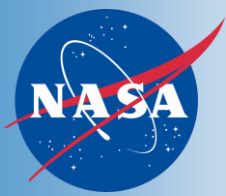
A two year

Technology Development & Demonstration Project



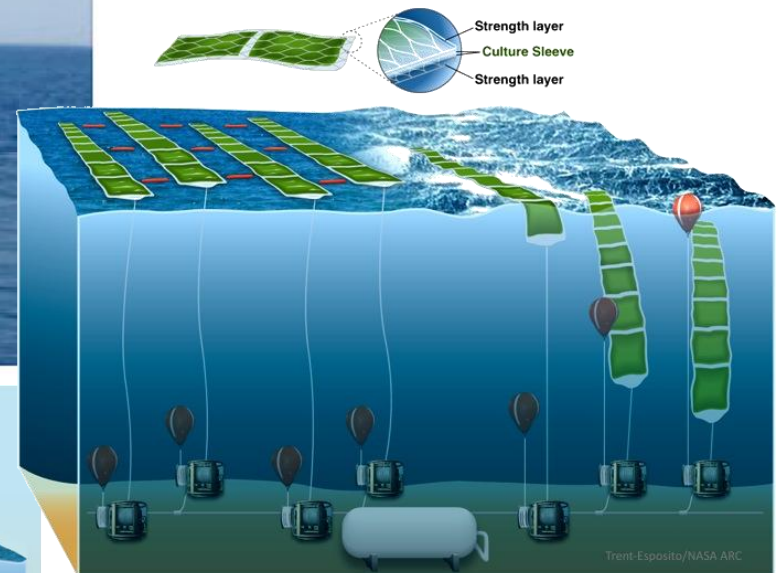
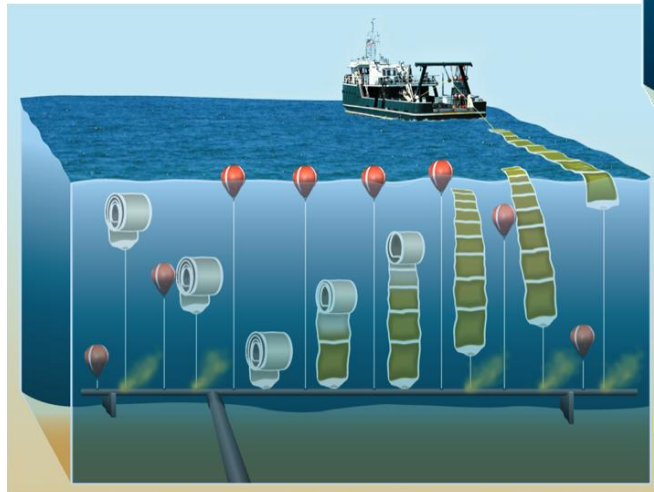
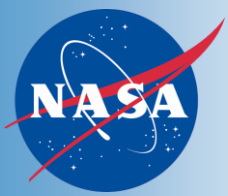
OMEGA Project Objectives

- O1:** Design, develop and build a ~~modular~~ algal cultivation system that utilizes and treats wastewater and is sufficiently scalable to be relevant for biofuels.
- O2:** In less than two years, deploy and operate an OMEGA pilot system for repeated algal growth cycles.
- O3:** Develop protocols to maintain the OMEGA system under various conditions in marine environments.
- O4:** Evaluate the OMEGA return on investment for both energy, economics, and do a complete life cycle analysis to determine its impact on the environment.
- O5:** Develop partnerships with DoD, DoE, and/or industry to transition and implement large scale OMEGA projects.



OMEGA Project Phase I

- January 2010 to June 2010
- Preliminary Engineering Studies
 - Concepts of Operations
 - Bioreactor Process Analysis
 - OMEGA Module Designs
 - Materials Selection
 - PBR Structural & Anchorage Studies
 - Infrastructure Needs

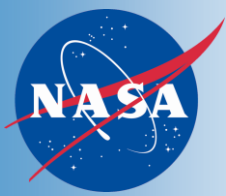






OMEGA System Components

- Systems to Deliver Wastewater and CO₂
- Floating Photobioreactors (PBRs)
- PBR Anchorage Systems
- Systems for Harvesting Biomass
- Instrumentation and Control Systems

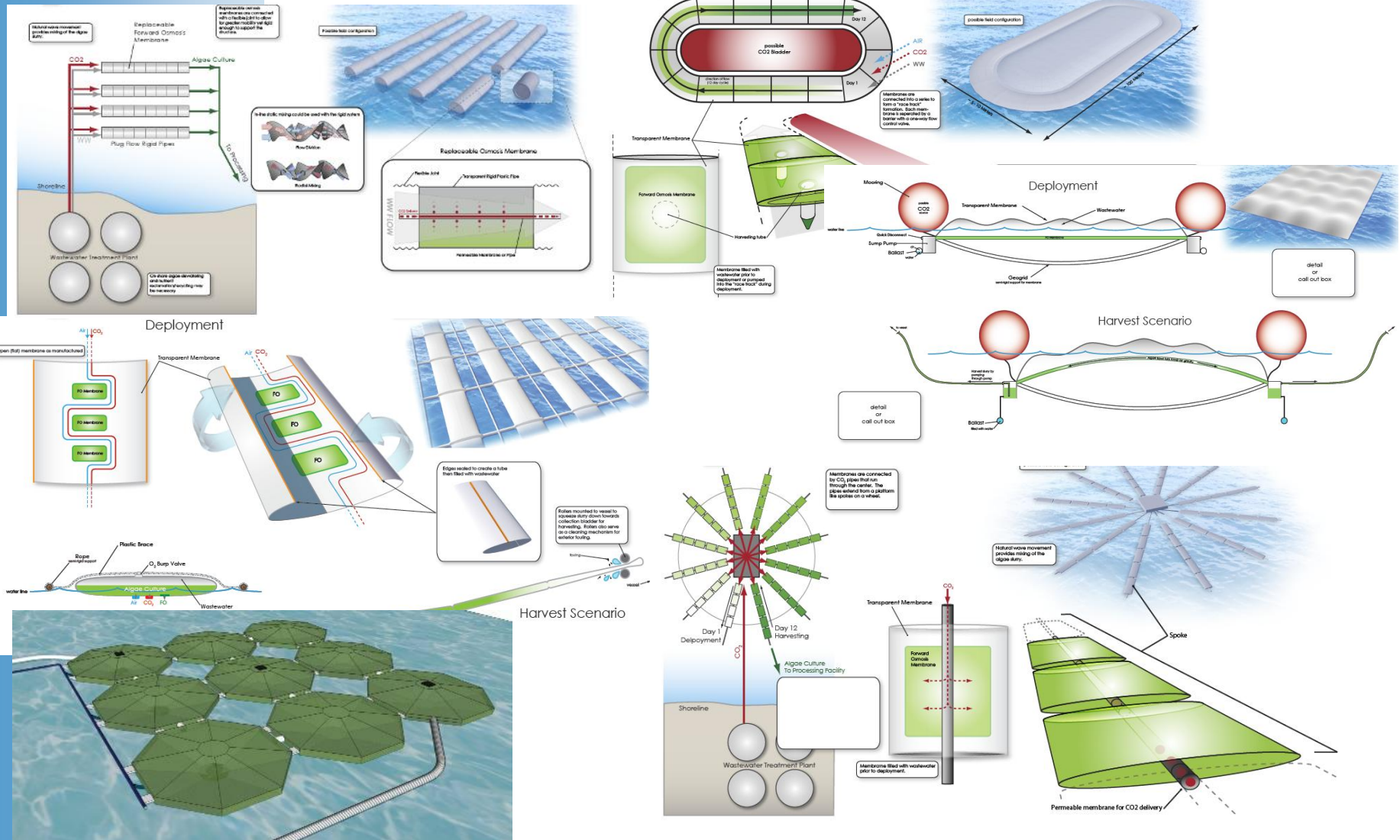


PBR Design Features

- Delivery of CO₂ to Algae Culture
- Air Sparging for Oxygen Striping and Mixing
- Transparent Upper Layer
- Exhaust Ports to Vent Headspace
- Ports for Monitoring
- Ports to Deliver WW/Harvest Algae
- Interior Design for Mixing
- Attachment Points

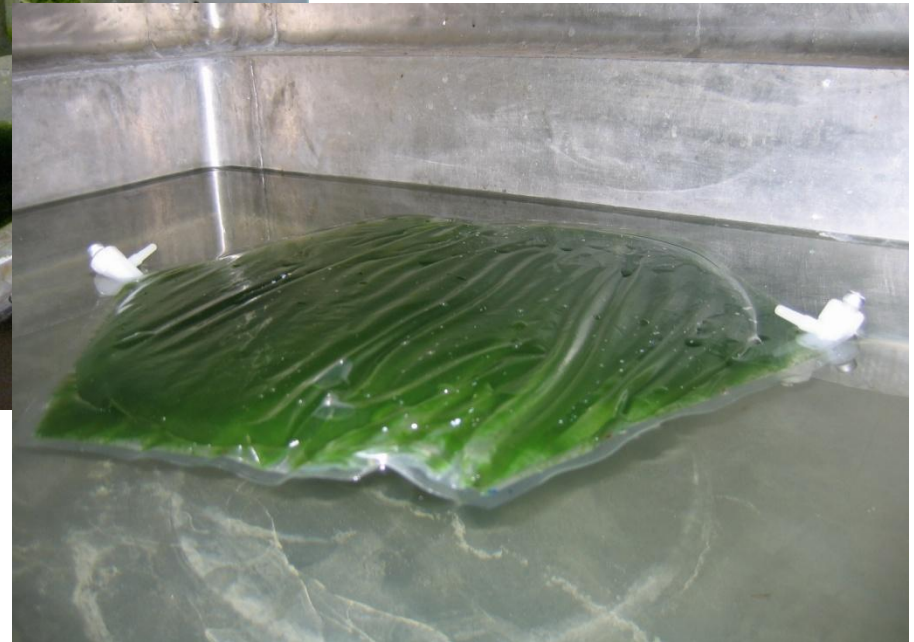


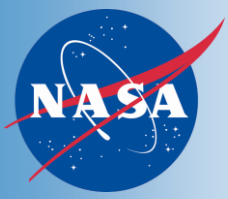
Multi-disciplinary Expert Workshop on PBR Design





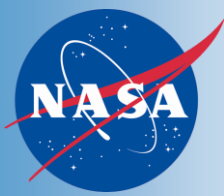
Bench Scale at ARC





California Fish & Game Testing Facility





Expert Review Panel: OMEGA Project



Moss Landing Marine Laboratories

8272 Moss Landing Road, Moss Landing, CA 95039-9647 USA Tel: (831) 771-4400 Fax: 632-4403
(<http://www.mml.calstate.edu>)

June 2, 2010

Dr. S. "Pete" Worden, Center Director
NASA Ames Research Center
Mail Stop I:200-3
Moffett Field, CA 94035-1000

Re: Letter of Support for OMEGA program

Dear Dr. Worden,

We are writing as members of the OMEGA Executive Level Review Board, convened at the request of Associate Center Director, Dr. Steve Zornetzer to provide an independent assessment of the OMEGA program and guidance to the project team. We are familiar with the program, having received written materials, electronic resources and two briefings to date. Although familiar with many aspects of marine science, none of us have any direct fiscal or current scientific interest in this program. Although we are not conflicted in this regard, we remain keenly interested in the potential that this project seeks to deliver.

Because the oceans can provide unique aspects for growing biofuels in terms of cooling, osmotic dewatering, mixing, conservation of arable land, etc., this project is of particular interest and concern for the marine scientist and policy experts. In our opinion the technology development that the OMEGA project seeks to achieve is highly worthy of pursuit. Unique opportunities exist to combine science with engineering, engage a multidisciplinary team that will address a socially relevant issue that represents one of the greatest challenges of our time. The Review Board feels strongly that a pilot scale program should go forward recognizing that the next phase will answer the question of how well microalgal biofuels can meet the our aviation needs of the future. The project has been well developed conceptually and demonstrated with some limited laboratory experiments and preliminary engineering studies, yet remains at a crossroads and cannot advance to the level of demonstration without resolving some of the larger design issues. It is important to do this study so that known issues can be resolved and unknown issues, identified. We note also that, within the marine science and policy arenas, the issue of marine spatial planning is moving ahead quickly. It will be important for the OMEGA program to articulate its requirements within that context.

It should be mentioned that the goal of this project is more important than some of the problems and resistance that will be encountered. In our opinion, it is appropriate that NASA takes a leadership role, including the commitment of resources and personnel (as well as reputation) to solve the sustainable energy challenges that face the nation. This is a tremendous opportunity and one that will advance the US on a path of leadership in engineering, innovation, sustainability. We look forward to strong commitment from NASA to help insure the success of this project.

In this regard, we find the OMEGA project to resonate strongly with the NASA National Plan for Aeronautics Research and Development as articulated in the recent Aeronautics Science and Technology Subcommittee report to the NST Council in 2007. Here, the need for a sustainable, economical, secure and reliable source of aviation fuel was articulated throughout this document as an environmental and national security imperative. It is completely appropriate that NASA take a leadership role towards the realization of these important objectives, and we strongly feel that the OMEGA program represents a bold step in this direction. Please feel free to contact any of us if you have any questions or concerns regarding this assessment.

Best regards,

Dr. Kenneth Coale, Director
Moss Landing Marine Laboratories
coale@mml.calstate.edu

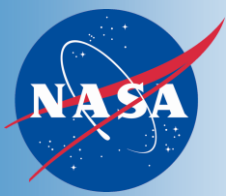
Dr. Jeff Paduan
Professor and Chairman of Oceanography
Naval Postgraduate School
paduan@nps.edu

Dr. Chris Harrold
Director of Conservation Research
Monterey Bay Aquarium
charrold@mbayaq.org

Dr. Chris Scholin
President and CEO
Monterey Bay Aquarium Research Institute
scholin@mbari.org

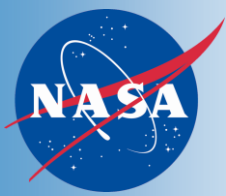
Mr. Luke Nachbar
Congressional Affairs Specialist
National Oceanic and Atmospheric Administration
Luke.nachbar@noaa.gov

Cc: Dr. S. Zornetzer



Phase I Preliminary Design Review

- Tony Strazisar, PhD, Senior Technologist (NASA HQ) *Chair*
- Capt. James Brown, Task Force Energy (USN)
- Zia Haq, EERE, Biomass Program (DOE)
- Joanne Morello, PhD, EERE, Biomass Program (DOE)
- Tina Panontin, PhD, Chief Engineer (NASA ARC)
- Carol Carroll, Deputy Director for Science (NASA ARC)
- Kim Wagenbach, Division Chief, Engineering (NASA ARC)
- Chad Paavola, Research Scientist, Bioengineering (NASA ARC)



Phase I Preliminary Design Review

**Review Panel Report
Preliminary Design Review of
Offshore Membrane Enclosures for Growing Algae (OMEGA) Project
June 7, 2010**

It was clear to the Preliminary Design Review (PDR) Panel that the OMEGA project team embodies the requisite expertise and understanding of biological factors and large-scale engineered systems to enable the OMEGA Project to achieve its goals. It was also clear from a post-PDR review of the Preliminary Engineering Analysis (PEA) that much more good work has been accomplished than could be presented in a one-day review....

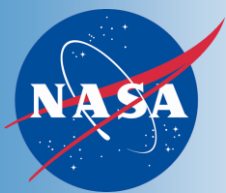
The PDR Panel recommends that the OMEGA Project proceed to Phase II. We also request a timely response to the eight Requests for Action (RFA) listed below....

*Tony Strazisar, PhD
Chair, OMEGA Preliminary Design Review Panel*

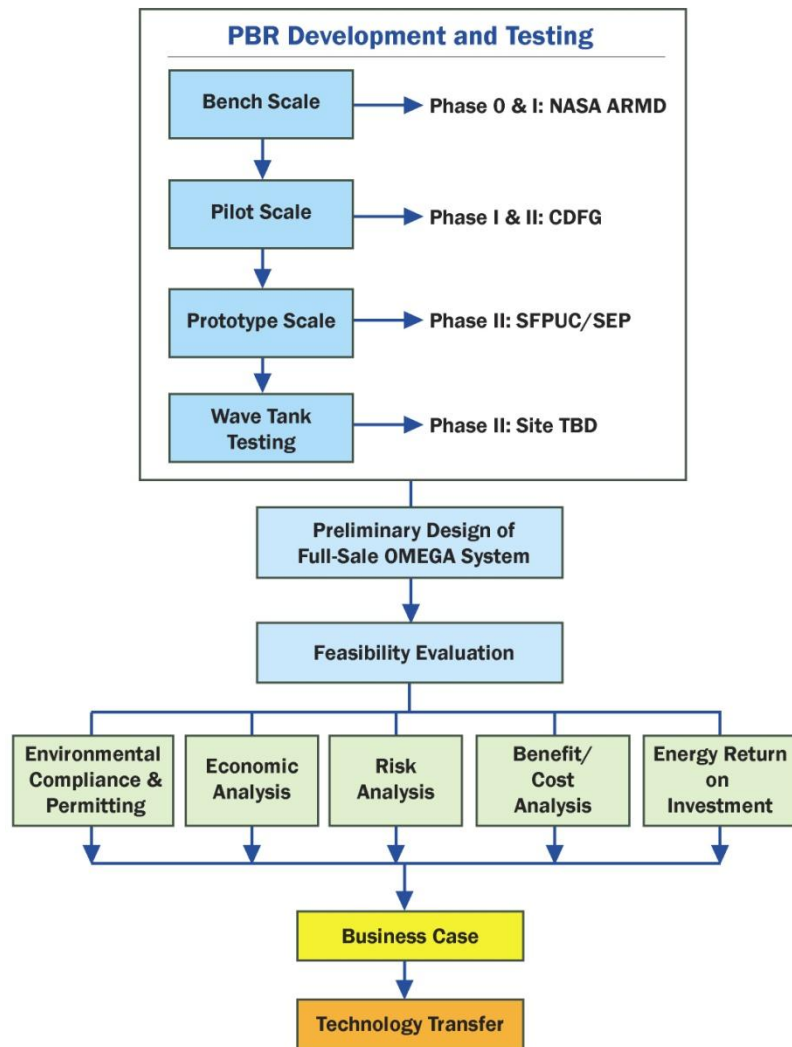


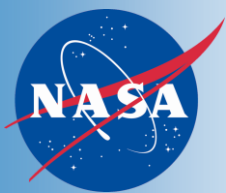
OMEGA Project Phase II

- September 2010 to March 2012
- Five Key Components
 - PBR Design and Testing
 - Preliminary design Full-Scale OMEGA System
 - Feasibility Analyses and Determination
 - Business Case
 - Technology Transfer

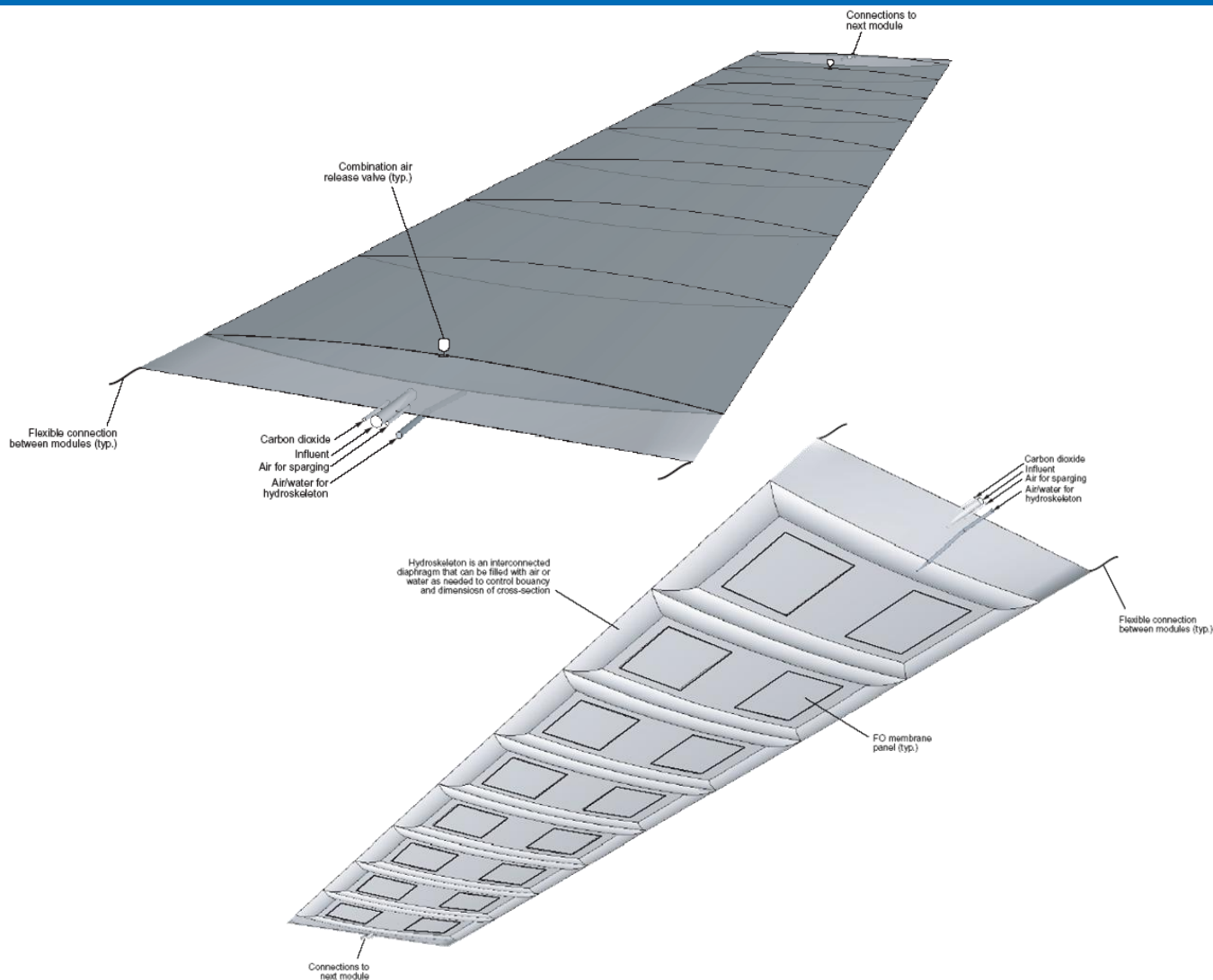
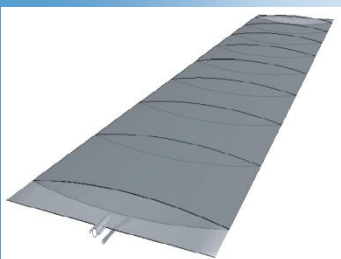
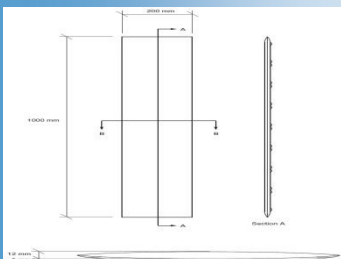
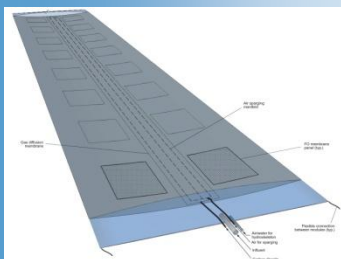
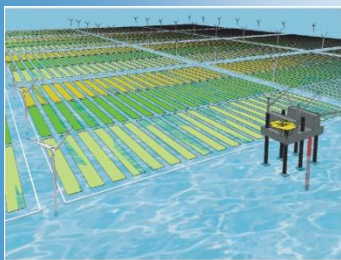


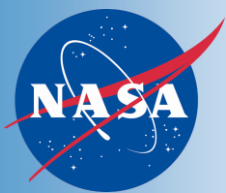
OMEGA Project



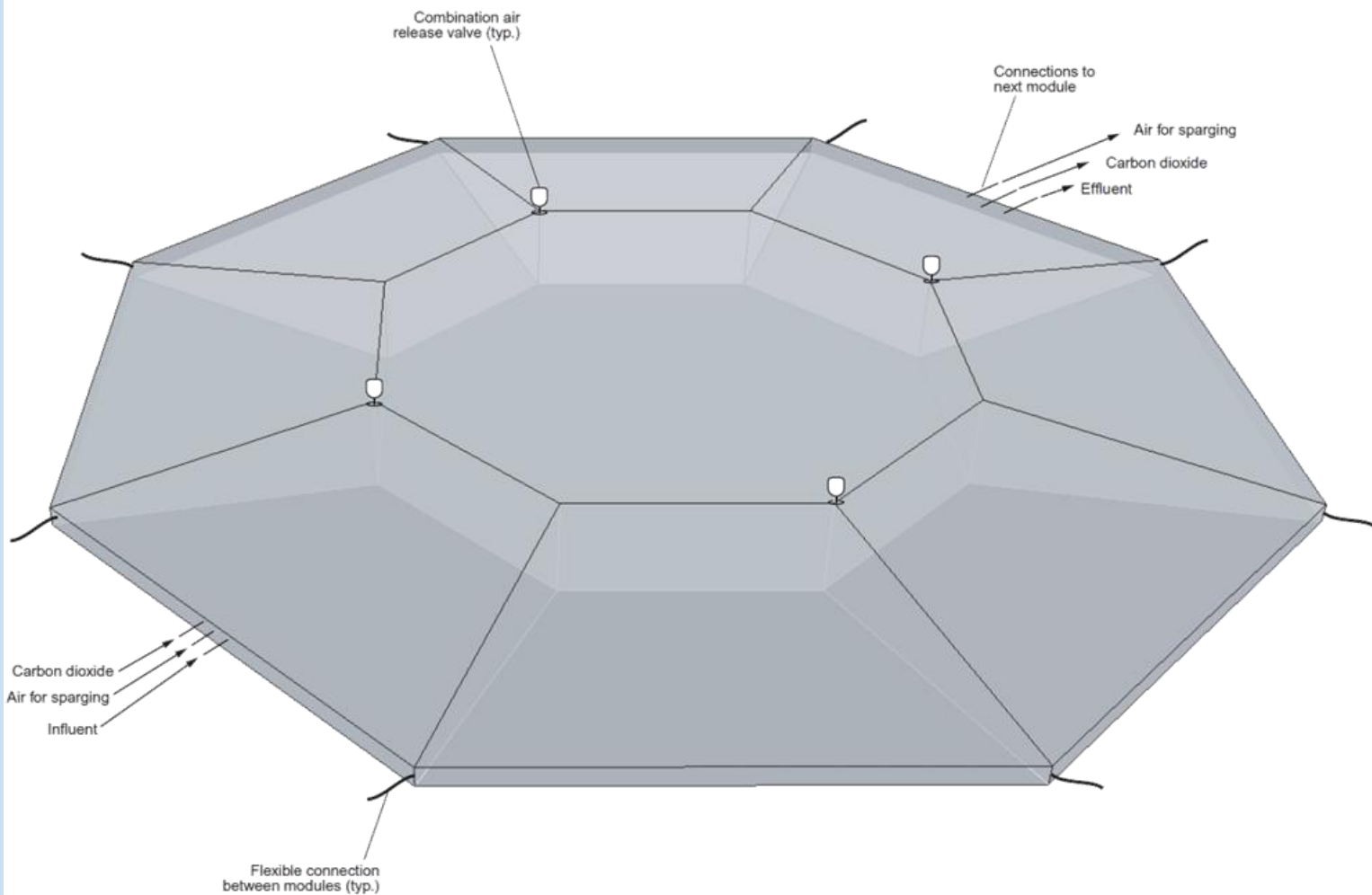
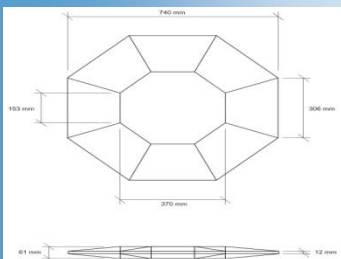
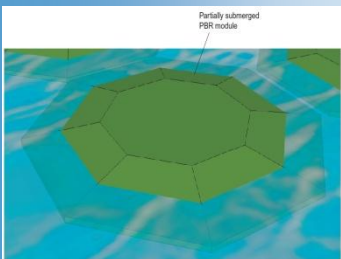
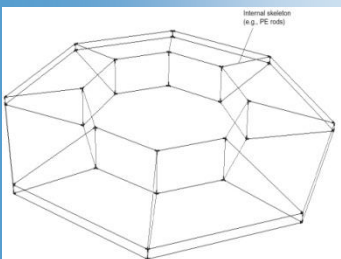
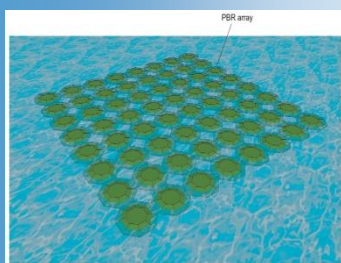


PBR Concept #1



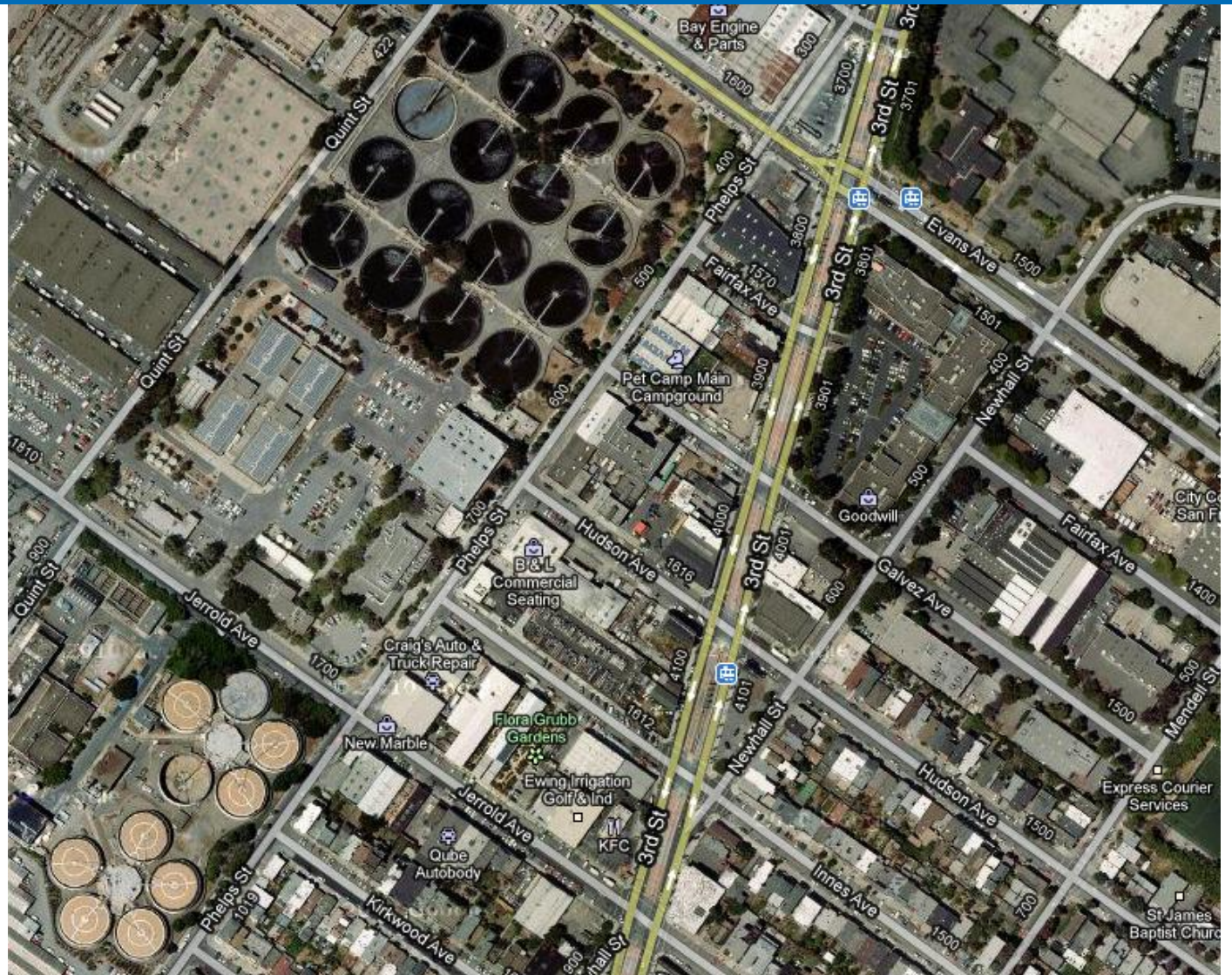


PBR Concept #2





Site for OMEGA Feasibility Test





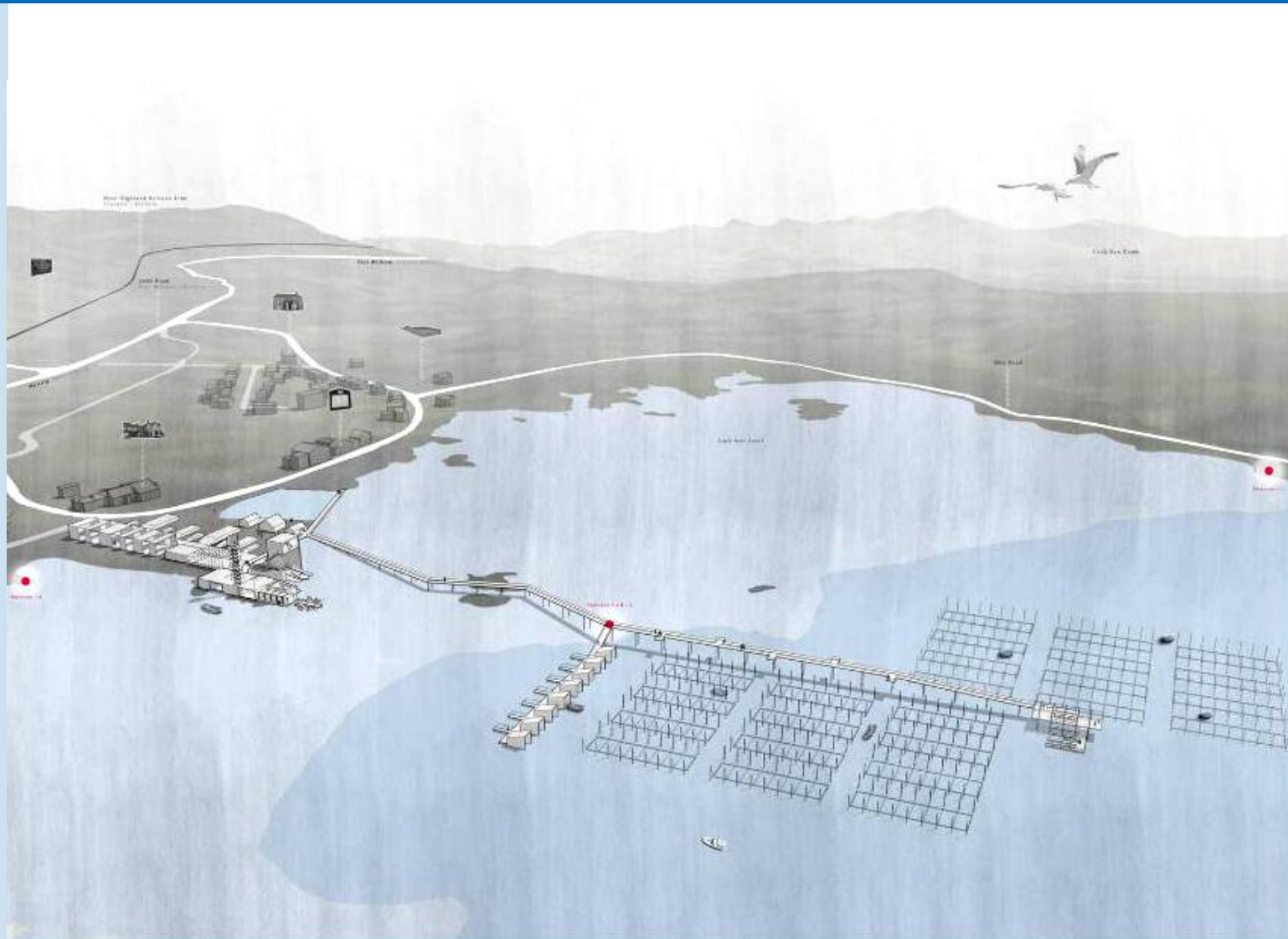
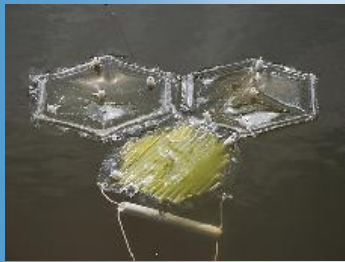
Retired DAF Tanks at SEP

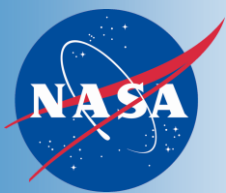




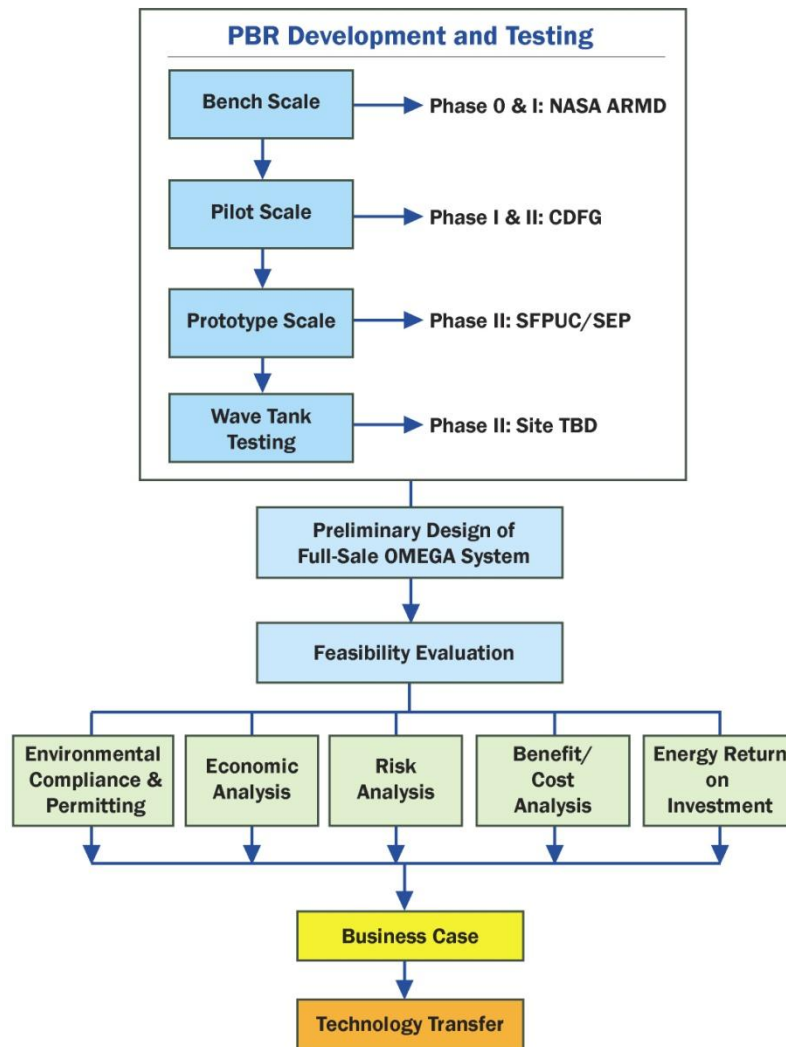


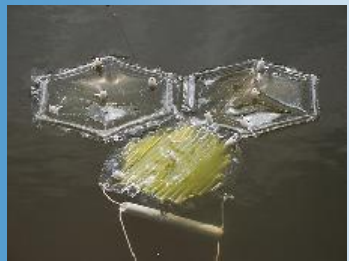
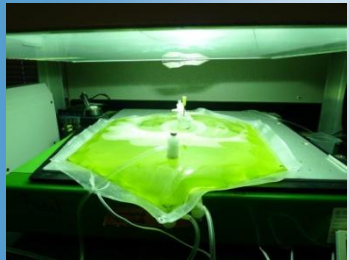
Offshore Algae Farming



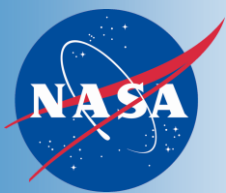


OMEGA Project

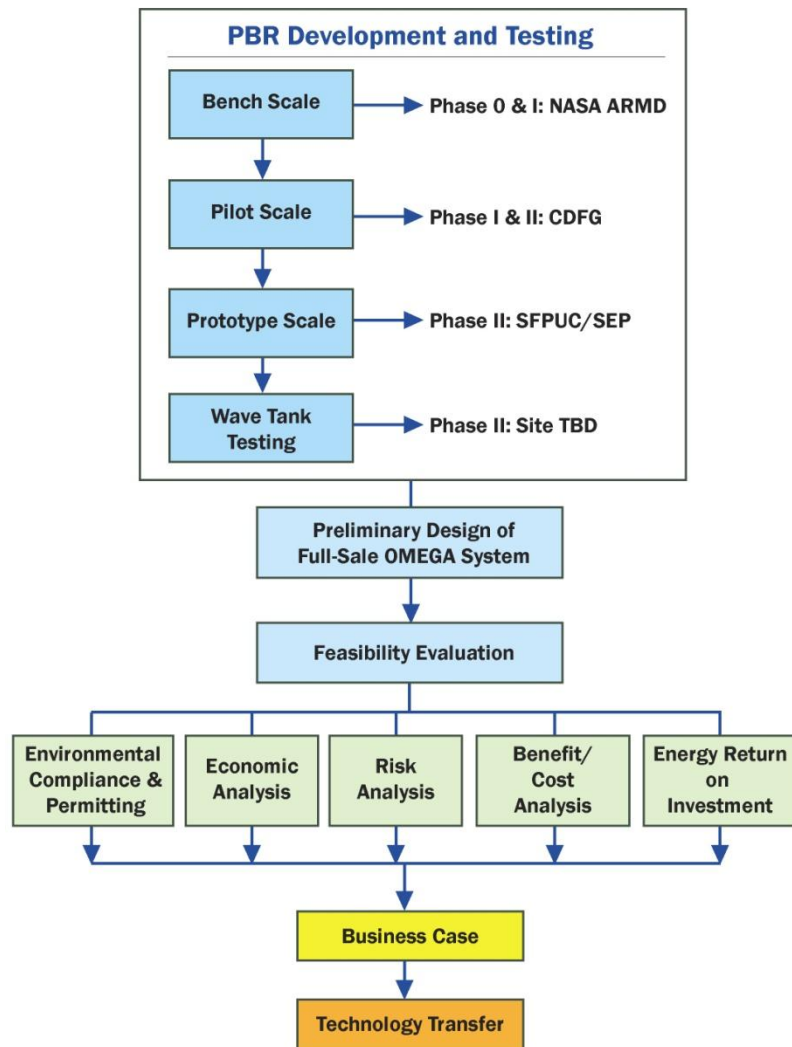


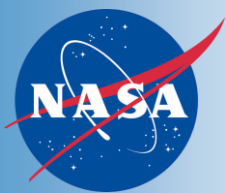


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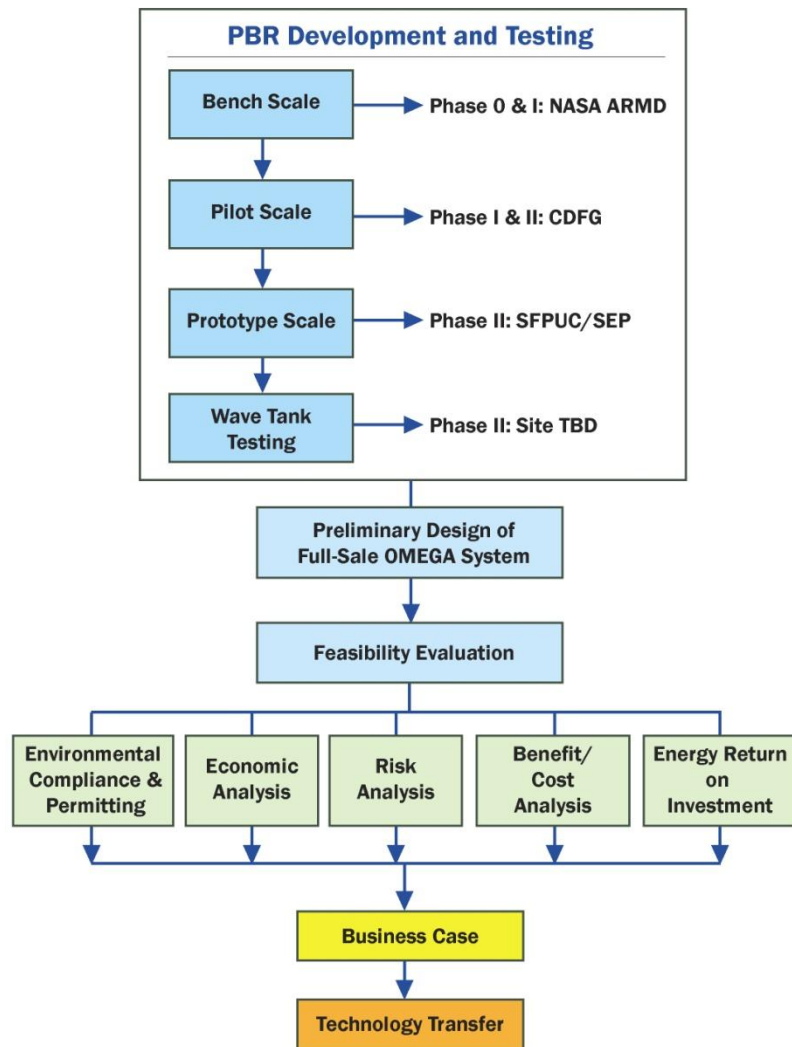


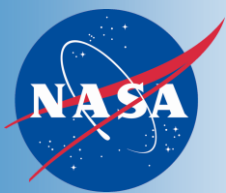
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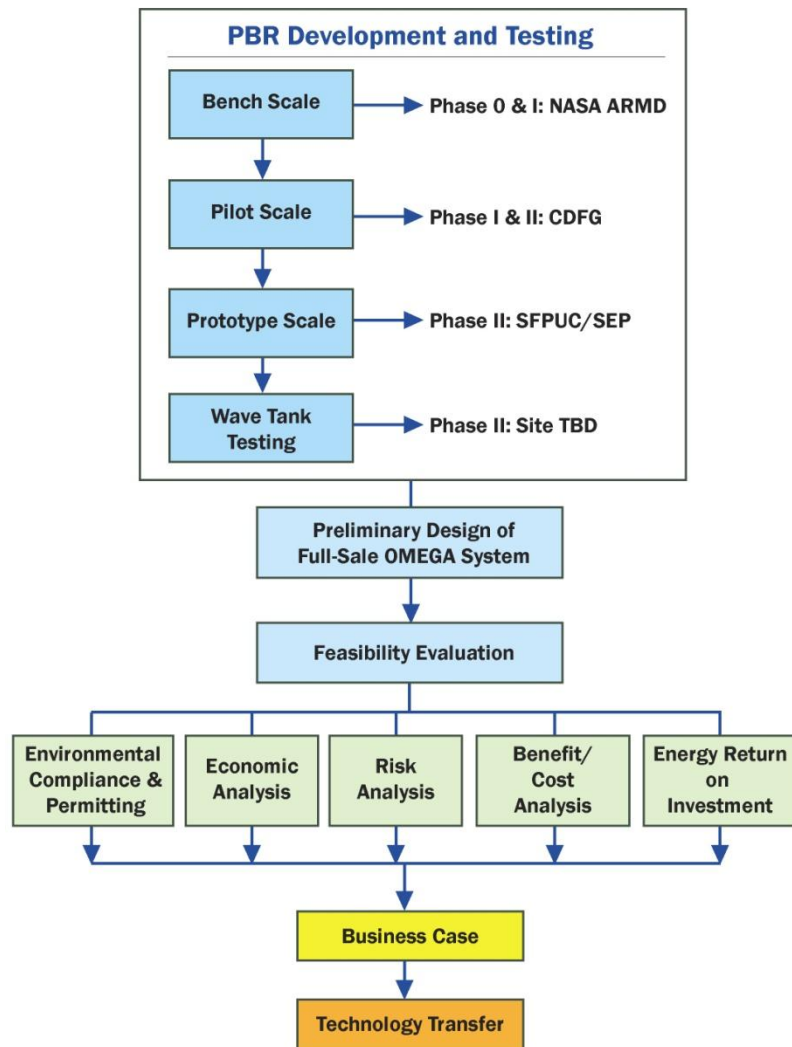


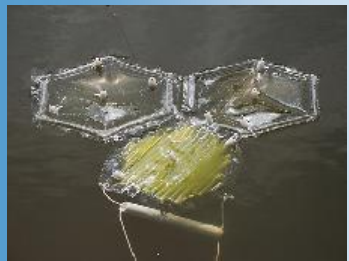
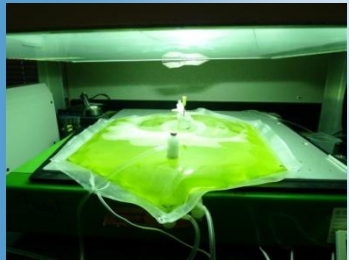
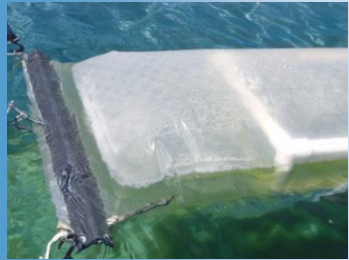
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OMEGA Project





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